1948

The uses of sodium selenate, P-40, and parathion in the control of red spider on ageratum.

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Lembach - 1948

THE USES OF SODIUM SELENATE, P-40, AND PARATHION IN THE CONTROL OF RED SPIDER ON AGERATUM

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Thesis submitted in partial fulfillment
for the degree of Master of Science
University of Massachusetts
Amherst, 1948

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ACKNOWLEDGEMENTS

Sincere appreciation is expressed to Dr. Frank Shaw, Professor Clark Thayer, and Assistant Professor Walter Banfield who, by their constant aid and interest during the course of the experiments, and helpful criticisms of the recorded information, made this work possible.

PREFACE

The purpose of the experiments recorded on the following pages was to find an efficient method of controlling red spider (Tetranychus telarius, Linne) on ageratum, a small flowering plant grown in greenhouse and gardens.

An attempt was made to keep these tests on an accurate basis with the considerations of the commercial aspects kept well in mind. Therefore the controls were handled much in the manner that they would be in a commercial greenhouse, only, of course, on a much smaller scale.

Originally the problem involved only the use of sodium selenate and P-40, the 2% sodium selenate in powdered superphosphate form. As the tests progressed however, literature became available on the advantages of Parathion in greenhouses and this method of control was investigated.

All the treatments gave a satisfactory amount of control, but the advantages of some methods, apparently equally successful, will be discussed in the section on Summary and Conclusion.

GREENHOUSE RED SPIDER

HISTORY AND DISTRIBUTION

The greenhouse red spider was first described by Harvey in 1893 as *Tetranychus bimaculatus*. He considered it distinct from the European species *telarius*, described by Linne, and later workers have failed to prove conclusively the identity of these two species, altho it is commonly accepted that the greenhouse red spider, or two spotted mite is of the genus *Tetranychus* and species *telarius*.

The first account of any serious injury caused by this mite in the United States came from the New England States, where it caused much damage to greenhouse plants. In 1855 a mite, since described by Banks as *T. gloveri*, but now known as *T. bimaculatus* Harv. was reported by Glover as doing injury to the cotton plants in the South. This injury increased in importance and in 1900 the Bureau of Entomology, U.S.D.A. established a southern laboratory to work on this pest. With the development of greenhouses in the West the ravages of the red spider soon appeared and caused serious damage to greenhouse plants as well as to many cultivated garden plants.

The red spider is very generally distributed throughout the United States from Maine to Florida and from the East coast to California except for the very arid regions of the West.

LIFE HISTORY

Greenhouse red spiders live almost entirely on the underside of leaves. The female lays about 60 spherical pearly white eggs which are so small that they are scarcely visible to the naked eye. Examination of infested leaves under a microscope will reveal these tiny eggs resembling dew drops attached to the underside of the leaf by a slender strand, or interwoven among the webs that the spiders are capable of spinning. These eggs gradually change to straw color, and in 4 or 5 days a round, colorless, six legged nymph hatches from each of them.

In developing from the egg to the mature spider one of two courses may be followed, dependent on the sex. With the female the egg hatches to a tiny six-legged form which, to be accurate, should be called a larva rather than a nymphy since it lacks one pair of legs which are gained in a later molt. The larva feeds actively for one day, changing to a light green color through the ingestion of plant material. The bright red or carmine eyes can also be seen at this time. At the end of this feeding period it becomes quiescent for a day. The term pre-molting has been applied to this period. The primary nymph or proto-nymph appears from this molt and it is at this stage that the spider first appears as an eight-legged form. After feeding for one day the primary nymph enters on another quiescent pre-molting period which is approximately the same duration as the larval quiescent period. From this pre-molting period there emerges the secondary nymph, or deutonymph, which is probably the most voracious of the immature mites. The deutonymphal stage is divided into an active feeding period and a quiescent period each of which requires one day for its completion. It is during these periods of ravenous feeding following the molts that cause the characteristic yellowed areas of injured plants. The adult female emerges from the deutonymphal stage which brings the number of days for complete female development to 7 to 8, under favorable conditions of temperature and humidity. Immediately following this molt the female establishes herself upon a leaf and feeds for several days before oviposition takes place. During this short period the female shows a tendency to migrate before mating. After mating it deposits about six eggs for about 8 to 10 days, making a total of over 50 eggs per female. The average duration of the female is about two weeks in summer but this may extend to a month or more as the cold weather approaches.

The average length of time required for the male, which can be considered the second course of development, is from seven to nine days. Although this period is only one day shorter than that required by the female, one complete molt, the second or deutonymphal stage is lacking. The fact that the two lengths of time required is nearly the same is due to the longer periods spent in the various molts by the male as compared to the female. Reproduction is practically continuous in the greenhouse and the insect seems to prefer the drier sections of plant to the moistened area or wet leaves. In cases of heavy infestation the spiders spin silken threads over the part of the leaf on which they are feeding and at times these webs may extend from leaf to leaf.

	Female	Male
egg	4-5 days	4-5 days
larva	1 1/4 "	2 "
quiescent	1 "	1 1/4 "
protonymph	1 1/2 "	2 "
quiescent	1 "	1 1/4 "
deutonymph	1 1/2 "	
quiescent	1 "	
adult	adult	adult

ORIGIN AND DISTRIBUTION OF SELENIUM

It is generally believed that selenium is present in lesser or greater degree throughout all soils as it is known to be throughout all igneous rocks. The presence of large amounts of selenium in a particular area is due to two factors. The origin of exceptionally large quantities probably is the result of decomposition of selenium from volcanic emanations in the Cretaceous seas, or in other periods where shale was produced. The fact that it is still present is due to the lack of rain in some areas or to the inability of rain to leach it from the soil in other areas, since it is often found in greater amounts in semi-arid areas than in areas of heavy rainfall. The existence of heavy selenium deposits has been established in most of the semi-arid and arid areas of the western United States and from the observations of geologists it is assumed that such areas also exist in Mexico and Canada.

The earliest recognition of the effects of seleniferous soils seems to be recorded by Marco Polo, who not only noted the effects of seleniferous plants and the avoidance of them by animals, but who also mentions the symptoms of what we now know to be "Alkali disease" and "Blind Staggers".

The first recorded mention of selenium or its effects in the United States was in 1856, the account of which will be discussed under the section on the toxic effects of selenium.

FACTORS INFLUENCING SELENIUM ABSORPTION

Trelease (1945) has stated that the amount of selenium absorbed by any plant is dependent on the selenium supplying power of the soil and the selenium accumulating power of the plant.

The selenium supplying power of the soil has been investigated from many diverse angles and there seem to be several theories regarding this ability of the soil. Most investigators are agreed on the various agents involved, but the importance and weight to be given to these agents is still very questionable.

Since different plants are composed of different proportions of the various elements, the statement is frequently made that plants exercise "selective absorption" or "feeding power". Edwin Miller in his text on plant physiology (1931) states that it has been assumed by some that the differences in the composition of plants are due primarily to differences in the specific absorbing powers of the roots. They consider that the absorbing cells of the roots differ in their ability to exclude certain elements more than others. One the other hand some consider that the difference in the amount of certain elements in the plants is due to the specificity of the protoplasm, which requires different proportions of materials for its development in different plants. The protoplasm of the developing cells is thus considered to regulate the amount of any given element in the plant rather than the regulatory action of the absorbing cells of the root. Miller states in conclusion that it seems fairly certain that the absorption of ions by plants is not a selective process in the strict sense of the term and the factors that control it are little or imperfectly understood.

The diversity of absorption of selenium is so complex that it has been found that some plants show absolutely no differences in growth when selenium is applied or present, some other plants will not grow on soils lacking selenium, and still other plants can be completely destroyed by selenium.

A review of the literature shows that the amount absorbed, as concerns soil abilities, can depend on the total amount of selenium in the soil, the distribution of selenium in the soil horizons, the chemical composition of the soil aside from the selenium, the chemical composition of the selenium, the origin of the selenium in the soil, or how it is applied - if applied intentionally. As regards the accumulating power of the plant still more factors must be considered as; the type of plant, the plant populations (kinds of plants present or formerly present), the stage of growth of the plants examined, the part of the plant analyzed (root, stem, leaf, and/or flower).

Trelease (1945) states that the presence in the soil of selenium that is capable of absorption has not been investigated thoroughly enough to allow definite conclusions. This is primarily due, he says, to the lack of an accurate method of analysis for detecting water soluable selenium that may be present in the soil. Also the exact chemical form of naturally occurring selenium in soils is not yet definitely known, altho it is believed that it is a relatively insoluble ferric selenite. It has been shown by Knight and Beath (1937) that plants can absorb much larger amounts of selenium from organic selenate and selenite compounds than they can from inorganic selenate and selenite compounds.

Using wheat as a basis for varied selenium absorption Hurd-Karrer (1937) has shown that there are other factors that affect the selenium content of the plant other than the concentration and composition of the selenium present in the soil. The experiments showed that the type of soil used as a growing medium definitely influences absorption. Sodium selenate applied to Keyeport loam was not easily leached from the soil and was at least partially retained in the upper surfaces. When quartz sand was added to the clay loam an increased toxicity to the plant was noticed. This fact seemed to be confirmed by this writer in one of the tests conducted which will be mentioned in the section on analysis of test #2 data.

Theory of selenium-sulphur antagonism.

In tests conducted in South Dakota in 1935 by Hurd-Karrer (Factors affecting the absorption of selenium from soil by plants) it was theorized that most plants absorb selenium due to their inability to distinguish between selenium and sulphur. Since the two elements lie close to each other in the periodic table and hence exhibit some similar chemical properties, and since sulphur is required for plant growth, experiments were conducted by that author to test the relative amounts absorbed by a plant when both elements were present.

The test plants were grown in soilesss culture and in soil culture with a definite amount of selenium compound in the growing media, but with varied amounts of sulphur present. The resulting plant vigor or injury was compared and it was found that those plants growing in a medium with a relatively large amount of sulphur present absorbed considerably; less selenium than those grown in an area where sulphur was present in a lesser degree.

This gave rise to the selenium-sulphur theory which later was the basis for extensive research and several modifications. Originally no notice was taken of the form in which the selenium was added. A few years later Beath and Knight (1937) showed that sulphur has an inhibiting effect only in certain forms. The general opinion now exists that selenium in the form of a selenate is absorbed in rates that can be influenced by the presence or absence of sulphur, and selenium in the form of a selenite is not affected by sulphur. Since plants absorb relatively little selenium in the form of a selenide this relationship has not been investigated.

Hurd-Karrer (1938) later showed that the addition of sulphur to plots containing organic selenate compounds had an effect on the amount of selenium absorbed. Analysis of plants showed that those treated with sulphur absorbed less sulphur than those untreated.

The same author in that paper also offered as further proof the following theory. An instance of plants that require large amounts of sulphur was proposed. The idea behind this was to show that the absorption was dependent proportionally on the demand of the plant for for sulphur. Assuming that the demand of the plant for sulphur affected the selenium content, plants that required relatively large amounts of sulphur should absorb large amounts of selenate. Conversely, plants that required relatively small amounts of sulphur should absorb relatively small amounts of selenium. In other words, since the volume of sulphur absorbed the same plants was greater than the volume absorbed by other plants, and all the plants were unable to distinguish between selenate and sulphur, then those plants absorbing the greatest amount of sulphur should absorb the greatest amount of selenium. This from previous experiments conducted by that author was almost immediately apparent and was easily confirmed.

Beath, Eppson, Gilbert, and Bradley (1939) helped further this theory when they showed that the mustard family, for example, which requires large amounts of sulphur for plant vigor, invariably shows a tendency for high selenium intake, while those plants which require less sulphur, as the cereals, have been associated with lower selenium intake. The legumes, since they fit between the extremes of low and high sulphur intake, quite naturally can be classified as absorbing selenate in medium quantities.

Perhaps it should be emphasized at this time that the quantity of sulphur is not the sole determing factor in selenium absorption. There are many factors, mentioned previously that will influence the amount of selenium absorbed by a particular plant. It is known that these various agents influence the amount absorbed. Just why the plant absorbs selenium is not fully understood and the selenium-sulphur theory has been advanced in the hope of explaining why any particular plant absorbs selenium.

SELENIUM INDICATORS AND ACCUMULATORS

Many western botanists and agronomists, among them Trelease (1945), Beath, Gilbert, and Eppson (1939), and Williams (1938), have shown that some plants actually thrive better when there is available selenium in the soil. In the floricultural uses of selenium the problem is usually one of applying the minimum amount of selenate required for insect control, since most plants are harmfully affected by selenate compounds. However, many plants native to the Western United States actually thrive on selenium. According to Trelease (1945) some of these weeds and grasses have been used as selenium indicators since they are capable of absorbing and storing large amounts of selenium although by weight of sample taken from the soil, there is not any great amount of selenium present. These plants, known as indicators, break down the selenium from some of the more complex forms that it is found in the soil, and with it form organic selenate compounds that are stored in the plant tissue. When the plant dies these compounds, then in the available organic form, are liberated in the soil and hence become available to other type plants that are growing in the same environment or in nearby areas. Byers and Knight (1935) state that most plants that cannot absorb selenium in the inorganic form are in the class of cultivated crops and western prairie grasses.

Trelease (1945) also mentions that plants which are known as accumulators can absorb up to 800 times the selenium absorbed by the crops and grasses. These include the vetches (<u>Astragalus</u>), the woody aster (<u>Xylorhiza</u>), and a relative of goldenrod (<u>Oonopsis</u>), and princess plume of the mustard family (<u>Stanleya</u>). Of the 23 species of <u>Astragalus</u> that absorb selenium it has been noticed that each of these need selenium for vigarous growth and without it seems to have difficulty reaching any semblence of maturity. It should be made clear that all species of <u>Astragulus</u> do not fall into this category since many other species than these 23 known as indicators or accumulators will grow equally well on seleniferous or non-seleniferous soils.

SELENIUM TOXICITY TO ANIMALS AND HUMANS

Selenium diseases appear to be unique in that they are, as far as it is known, the only diseases caused by vegetation made poisonous by an element absorbed from the virgin soil. Fortunately it is only present naturally in scattered areas and rates about fiftieth in order of abundance, being just about as rare as silver. It is commonly associated with sulphur of volcanic origin according to Byers (1936) and traces of it are found in most soils derived from shales over most of the United States, according to Byers, Williams, and Lakin (1936).

The problem of determing the cause of the diseases now associated with selenium was pioneered primarily by workers in South Dakota. The existence of the symptoms had been known for many years. In the early days of the development of the West the presence of selenium in the soil actually delayed the development of large sections of the country.

Trelease (1942) tells us that as early as 1856 these symptoms were recorded by Army officers in Nebraska. The most conspicuous symptoms in horses, pigs, and cattle were loss of hair and deformity and eventual loss of hoofs. The inability of the stock to walk prohibited them from reaching water and they eventually died of thirst, although if enough selenium was present in the forage, it was later shown by Moxon and Rhian (1943) that the animal would die of emaciation.

Soon after these symptoms were noticed in Nebraska some of the farmers of the region concluded that it was some mineral in the soil that was taken up by the plants that was causing the trouble. Scientists in South Dakota started a series of feeding experiments and eventually traced it to the grain in the animals' diets. In 1931 a survey of the soil was made by the Department of Agriculture and it was discovered that the toxic vegetation occurred on soils derived from Pierre shales. This clue led the soil chemists to suspect selenium, an element that might reasonably be supposed to exist in shales, and known to be poisonous to animals. From there it was a relatively simple matter to clinch the evidence by feeding laboratory animals various grains grown in seleniferous or non-seleniferous soils and note the effects - which in the case of those fed on grain grown in seleniferous grain produced symptoms in the animal that were similar to the symptoms noted in the field.

The disease known as "Alkali", although actually a misnomer since it is not caused by alkali in the soil but selenium, presents the symptoms described before, e.g., loss of hair and deforming of hoofs. Hurd-Karrer (1935) and Byers (1937) describe the more advanced stages in which the animals show a tendency to wander aimlessly and eventually lose coordination of movement. In this stage the animal is liable to a very sudden breakdown since, when it has grazed on heavily selenized vegetation, it shows no immediate effects, but when the symptoms become apparent they are much more intense than in the case of "Alkali" disease. These effects were also recorded by Rosenfeld and O.A. Beath in 1941 and by Moxon (1937).

As a general figure cows cannot tolerate more than 15 parts per million selenate in their daily feeding, according to Moxon and Rhian (1943), and smaller animals can tolerate even less.

Trelease (1945) maintains that most animals seem to avoid grazing on the type of weed that has a large amount of selenium in its tissue, especially if it is a species that has a selenate content high enough to produce a selenium odor. Usually there is more danger to livestock, he says, from plants that have only a small or moderate amount of selenium since these species of plants or weeds are more palatable and eaten more freely.

There are broadly two classes of seleniferous weeds in the opinion of O.A. Beath (1937). The first type is believed to grow only on soils that have been derived from certain formations and contain toxic amounts of selenium. This includes species of *Xylorhiza*, *Stanleya*, *Oonopsis*, and *Astragalus praelongus* and *A. grayi*. The second type includes the species that can grow equally well on seleniferous or non-seleniferous soils, which include certain species of *Astragulus*.

The harmful effects of selenium on animals quite normally led to considerations of its effects on humans.

Originally it was believed that man's diet was so diversified that there was little danger of accumulation of selenium to such an extent as to cause any toxic effects. At present however, as a result of tests performed by Franke (1934) and Smith (1937) and (1939) there are many precautions advised in connection with the use or handling of selenium, and the possibilities of selenium effects from selenized foods. In 1936 M.I. Smith of the U.S. Public Health Service made a preliminary survey of some of the rural population in parts of South Dakota, Wyoming, and Nebraska. Among 111 families studied 92% of the 127 urine samples examined showed positive for selenium content and contained from .02 to 1.33 parts per million. Since there were no definite symptoms that could be ascribed to selenium with certainty it was assumed that man could tolerate this concentration.

Since from experiments with smaller animals by Moxon and Rhian (1943) show that small amounts of selenium may be toxic, the precautions to be exercised in handling the pure forms used in insecticidal work must be carefully observed. It is advised that rubber gloves or some such suitable covering be used for the hands when the insecticide is being applied or handled in any method.

If the skin comes in contact with the solutions soap and water should be used to remove all traces. In greenhouse work the employees should know what sections of the houses contain selenized plots and care should be taken that these areas are not worked by hand, or if this is not possible, that the workers wash their hands immediately after handling the soil.

A great amount of care must be taken that the soils used for growing plants treated with selenate are not re-used for growing any edible crop at a later date. It is possible that the soil may have all the selenium removed in approximately four months but the hazards involved in re-using the soil are too great compared to the comparatively easy task of obtaining new fresh soil. When the soil is removed care should be taken that it is not dumped in fields where it may accidently be re-used.

USES OF SODIUM SELENATE

Sodium selenate has its greatest use against sucking type insects. It is generally necessary for the insect to pierce the leaf tissue and suck the plant juices which carry the selenate. It will kill red spider, aphids, chrysanthemum midge, foliar nematode, and many thrips but its use is curtailed due to the toxic effects it may produce to the plant and to its inability to move up the stems of woody plants.

SODIUM SELENATE TEST #1

Preparation

Ageratum plants used in this test and the following tests were obtained from the ageratum stock plants in the University greenhouses. They were taken in two large groups of cuttings to provide plants in different age groups. In this manner the effects of the insecticide on the plant health and growing condition could be noted. It has been noted by Neiswander and Morris (1940) that sodium selenate of a definite concentration will control red spider on some plants with little or no injury. If, however, this concentration is applied to the same variety of plant or type crop and the specific plants subjected to the treatment have not reached a certain age, plant injury make take place. It was the purpose of this writer to see if ageratum treated with a selenate compound would react in a similar manner. The results obtained with different age plants will be discussed in the analysis of data section in ensuing tests.

All the cuttings taken from the stock plants were rooted in constant water level benches with sand as the rooting medium for propagation. The cuttings rooted in approximately two weeks and then were removed and placed in 3" pots until they were needed. The potted plants were subject to several different environmental factors before they were treated which later showed some bearing on the final results obtained as regards plant tolerance.

The red spiders used to infest the plants were obtained from several sources rather than one isolated infestation. To make certain that the spiders used were not weakened or that they favored any particular combination of ecological factors, infested leaves of various small succulent plants and floral and vegetable crops were taken from the Durfee greenhouse range, the greenhouse managed by the botany department at Clark Hall, and from several greenhouses at French Hall -- all on the University grounds.

These leaves or sections of lead were placed on the potted ageratum plants which were placed close enough together so that the leaves of one plant touched the leaves of another, providing avenues for dispersal of the insect population.

The soil used in the first test was obtained from a chrysanthemum greenhouse bed. It was considered a medium heavy loam with a relatively small amount of fertilizer. In several of the later tests this soil was mixed with sand in the ratio of 75% loam to 25% sand. For some unexplained reason plants seem to absorb selenate compounds from coarser amounts than they do in a finer medium. Although there was no intention of investigating this phenomena, the results and different effects were recorded for those later tests in which sand was used.

The stock solution was prepared by weighing out a quantity of sodium selenate and diluting it with water at the rate of 199 grams of sodium selenate / 1 gallon H_2O. This proportion is the suggested concentration of stock solution for carnation treatment and hence was chosen as a matter of convenience to the grower if the results obtained proved positive.

The stock solution was thoroughly mixed and then placed in four stoppered bottles for easy handling. It might be well now to note that it is necessary to shake these solutions vigorously before using since the selenate settles out of solution in a relatively short time. Only very small amounts of the stock solutions are used in the final spray concentration and it is of prime importance that the part of the stock solution removed is a true representative sample or else plant injury from overstrength, or poor control from understrength solutions may occur.

The testing areas were regular greenhouse benches, eight feet long and three feet wide. In the tests involving ageratum grown in benches (as opposed to those involving ageratum grown in pots) the benches were divided into four equal areas, two feet by three feet. They were separated by wooden crossbars that were nailed to the sides and base of the bench, and sealed one section from its neighbors. In this manner three areas could be sprayed with three different concentrations of the insecticide and one area could be left unsprayed for use as a check plot.

Purpose and method.

The purpose of this first test was to find the coarse limits of concentrations that would be tolerated by the plant and yet give some reduction in red spider population. It was not entered upon with intentions of obtaining final results, but rather as an attempt to find the uppermost extreme concentration, in a very general sense, that would be tolerated by the plant, and the lower extreme concentration that would noticeably reduce the population. In other words, it was a series of tests used as indications of just how much selenate the plant could absorb without foliage burn, and just how much the stock solution could be reduced and still have some effect.

For this reason, the many factors that were considered and recorded in later tests were not necessary in this series, e.g., factors as plant age, temperature and humidity, were not considered.

The plants were subjected to the three concentrations which are listed on the first page of the following section on tabled data.

After the stock solution had been diluted to the concentrations listed the soil was sprayed by means of an atomzier on the three sections to be treated and one area was left unsprayed as a control check. Actually the atomizer is not needed, nor is it advised for growers using sodium selenate. In this instance, however, it seemed worthwhile to get a thoroughly uniform application which, since the amounts were small and the areas restricted, was best provided by the use of an atomizer.

The areas were left undistrbed for one day after the spray was applied and approximately twenty four hours later they were watered to leach the selenate thru the deeper layers of the soil and to prevent the accumulations of spray material from remaining on the surface. The following day, when the beds had dried a bit which permitted easier handling of the soil, 64 plants were removed from pots and placed in the beds. They were arranged in groups of 16 to each area, in 4 rows of 4 plants each. At this time they were about one month old. Since the leaves of the plants, in some instances, still had particles of the treated soil clinging to them, they were washed with a light water spray.

Thereafter, at definite time intervals, the leaves were examined and the number of spiders recorded. It was necessary to remove some of the leaves, for the sake of accuracy, in each of the areas and examine them under a microscope. This was accomplished by carefully removing ten leaves from each of the treated areas and ten from the check plot. In the tables that follow the figures are all actual counts and in no way approximations of the inhabitants of the leaf. The figures represent the total number of adult red spiders and nymphs.

Ten leaves were chosen rather than any other amount since this permitted extensive enough sampling and yet did not affect the vigor of the plant. If a larger number of leaves were taken from the plant the factor of plant condition would be artificially influenced which would introduce another variable factor as regards tolerance of the plant to selenium, since it has been found that plants that have a good vigorous growth can stand heavier concentrations of selenate, while those that are not growing at a normal rate may be more easily affected by the insecticide.

The general idea of sampling in this manner was to obtain data that could be both tabled and graphed and hence would show the comparative effects, if any, on the insect population. The sampling was, as far as possible, uniformly made. Leaves were taken from all parts of the plant and each sample taken from a plot was obtained in a pattern similar to the samples taken in all the other plots.

Explanation of Data Sheets

The stock solution and its dilutions forming the various concentrations are listed in cc/quart of water mainly to aid in proper dilution by any grower using such solutions. The dilutions into the multiples or fractions of quarts presents an easy method for accurate dilution rather than the less familiar cc/liter or fractions thereof.

In the tables recording insect populations the figures listed are the number of adult spiders and crawling nymphs. These stages were selected as a basis for control check for two reasons, primarily because it is during these stages that the insect is capable of injuring the plant and secondarily because it presented less difficulty in obtaining accurate figures than if the egg stage was included.

The letters "A", "B", and "D" represent areas treated with different concentrations of the insecticide (listed on the first page). The letter "C" represents the untreated area used as a control check, as it does in all later tests. The number "1" signifies that it was the first series of tests.

Populations were observed and recorded as long as it appeared that the plant was not affected to such a degree as to make it commercially unsaleable. After the selenium burn reached such severity the counts were discontinued on those particular plots.

CONCENTRATION OF SOLUTIONS

Stock solution: 49.75 grms. sodium selenate in 1 qt. H_2O.

A-1 29.5 cc. stock solution. / 1 qt. H_2O approximately 1/32 qt. of the stock solution.

B-1 49 cc. stock solution / 1 qt. H_2O approximately 1/16 qt. of the stock solution.

C-1 Control check - no selenate applied.

D-1 14.75 cc. stock solution / 1 qt. H_2O approximately 1/64 qt. of the stock solution.

4 Feb. 1948

A-1

# leaves	1	2	3	4	5	6	7	8	9	10	total
# spider	0	2	0	3	1	4	0	1	2	3	16

B-1

# spider	0	7	0	1	4	0	6	4	0	0	22

C-1

# spider	0	1	0	1	9	0	2	5	2	0	20

D-1

# spider	4	0	0	3	2	3	0	0	5	0	17

A-1 no signs of injury

B-1 no signs of injury

C-1 no signs of injury

D-1 no signs of injury

11 Feb. 1948

A-1

# leaves	1	2	3	4	5	6	7	8	9	10	total
# spider	0	0	0	0	1	0	1	0	0	0	2

B-1

# spider	0	1	0	0	2	0	0	0	0	0	3

C-1

# spider	3	0	1	0	5	20	0	0	0	0	29

D-1

# spider	1	1	1	0	0	0	0	0	0	0	3

A-1 no signs of injury

B-1 slight burn evident

C-1 no signs of injury

D-1 no signs of injury

18 Feb. 1948

A-1

# leaves	1	2	3	4	5	6	7	8	9	10	total
# spider	0	0	0	0	0	0	0	0	0	1	1

B-1

# spider	0	0	0	0	0	0	0	0	0	0	0

C-1

# spider	2	1	11	4	0	8	23	1	6	2	57

D-1

# spider	0	0	0	0	0	1	0	0	0	0	1

A-1 slight selenium burn

B-1 strong selenium burn

C-1 no signs of injury

D-1 no signs of injury

25 Feb. 1948

A-1

# leaves	1	2	3	4	5	6	7	8	9	10	total
# spider	0	0	0	0	0	0	0	0	0	0	0

B-1

# spider	0	0	0	0	0	0	0	0	0	0	0

C-1

# spider	11	1	4	10	0	11	22	0	3	1	63

D-1

# spider	0	0	0	1	0	0	0	0	0	0	1

A-1 slight selenium burn

B-1 severe burn

C-1 no signs of injury

D-1 growth reduced about 10%

3 March 1948

C-1

# leaves	1	2	3	4	5	6	7	8	9	10	total
# spider	2	5	6	2	6	1	2	17	36	22	99

D-1

# spider	0	0	0	1	0	0	0	0	0	0	1

A-1 severe burn

B-1 severe burn

C-1 red spider injury evident

D-1 growth reduced about 10%

10 March 1948

C-1

# leaves	1	2	3	4	5	6	7	8	9	10	total
# spider	28	7	4	11	13	7	0	5	15	4	94

D-1

# spider	0	0	0	0	0	0	0	0	0	0	0

A-1 severe burn

B-1 severe burn

C-1 red spider injury evident

D-1 growth reduced about 10%

17 March 1948

C-1

# leaves	1	2	3	4	5	6	7	8	9	10	total
# spider	2	0	19	14	5	0	0	11	9	10	70
# "	0	2	22	12	11	7	3	9	19	9	94
# "	0	2	3	2	92	2	11	28	4	17	151
# "	23	2	1	15	39	8	16	7	3	4	118
# "	44	21	7	0	3	2	61	53	33	6	231

50 leaf total. 664

spiders / 10 leaves. 133

D-1

# leaves	1	2	3	4	5	6	7	8	9	10	total
# spider	0	0	0	0	0	0	0	0	0	0	0
# "	0	0	0	0	0	0	0	0	0	0	0
# "	0	0	0	0	0	0	0	0	0	0	0
# "	0	0	0	0	0	0	0	0	0	0	0
# "	0	0	0	0	0	0	0	0	0	0	0

50 leaf total. 0

spiders / 10 leaves. . 0

A-1 severe burn

B-1 severe burn

C-1 spider injury evident

D-1 growth reduced about 10%

ANALYSIS OF TEST #1

The results of this test indicated the general uppermost limit of concentration that could be safely applied to ageratum. Of the three areas treated all but one showed evidences of burn and the one section that remained unburned seemed to lack the normal growth expected by comparison with the check plot.

Area "B", the most heavily affected plot showed signs of burn in about two weeks, indicating that the concentration was far too strong, since plants normally show burn only after three weeks to a month. The fact that these plants may have been growing at a good rate may have shortened the time for burn to become evident as it is known that rapidly growing plants will absorb selenate more quickly from the soil than the older, less rapidly growing plants.

Area "A", moderately treated in comparison with "B" and "D", showed evidences of burn about three and one half weeks after application, but soon after the signs of injury became more marked and eventually the plants were considered too much harmed for further investigation.

Area "D" prompted the start of tests centering about the concentration used for this plot. During all the time observed it showed no signs of burn. There was however, a reduction in growth, which although of no great extent, was still noticeable. By way of comparison it can be said that the growth was about 10% less than that of the control check. Since ageratum is not sold commercially on the basis of plant height as are the cut flowers, this phenomena would not prove a hindrance in its saleability. However, other tests were undertaken to see if the concentration could be lowered enough so that growth would not be impaired and control still could be obtained.

In those plants that were burned there was, as would be expected, no evidence of red spider. In "D" the population started to decline about two and one half weeks after treatment, which is a much shorter time than was expected - one month being the usual time required by other type plants for population reduction according to White and Whitcomb (1942).

At the end of two months a very extensive check was taken of this area and of the fifty leaves examined there was not one red spider and no evidence of red spider injury. On the control check plot, which was untreated, examination of fifty leaves showed 664 spiders and extensive discoloration of the leaves as a result of their feeding.

The rapidity of burn, due to the age of the plants gives an indication for the quick evidences of control. The plants at the time of treatment were about 5 weeks old and hence were in a period of rapid growth which explains the quick burn since they absorbed the selenate rapidly, and in the case where the plants showed no burn light concentrations of selenate were quickly absorbed.

TEST #2

Purpose and method

From the results in test #1 a second block of controls was arranged to determine the following:

1. Could the concentration be lowered and give adequate control without affecting the height of growth.
2. The effects of selenium on plants of various stages of growth.
3. The effect of adding sand to the growing medium.

The arrangements of treated areas was much the same as in test #1 but instead of 4 rows of 4 plants each, these areas had two rows of four plants each with one month's difference in age. The young and older plants were treated with equal concentrations in each area.

The soil used was similar to that in test #1 but 25% sand was added and mixed with the soil before the plants were removed from the pots and placed in the various areas.

The concentrations listed in the following data sheets were chosen for these reasons; one concentration was higher than "D" of test #1 to serve as a check on the uppermost limit of plant tolerance and the lower concentrations used on B-2 and A-2 were an attempt to reach conclusions on "1" listed above as a purpose of the test. The method of application of insecticide and treatment of the plants in moving them into the beds is the same as the method outlined in preparation for test #1.

Explanation of data sheets

Plants labelled as old in the following tables were grown from cuttings secured on December 18, 1947 and were placed in pots on January 3, 1948. Plants labelled as young were obtained from cuttings secured

January 14, 1948. All the plants were placed in 3" pots until benched and as such were placed under the greenhouse beds for further use. This was necessitated by lack of room on the benches and resulted in a much poorer type plant than those used in test #1. However, after they were moved to the benches and fertilized they appeared normal. It is not known if this period of poor growth had any effect on the plant tolerance but it is assumed that the effect, if any, was negligible since the plants were in good condition before there were any effects of selenium injury.

All other data is similar to the tables in test #1.

CONCENTRATIONS APPLIED

A -2 8 cc. stock solution / 1 qt. H_2O approximately 1/128 qt. / 1 qt. H_2O.

B-2 10 cc. stock solution / 1 qt. H_2O approximately 1/96 qt. / 1 qt. H_2O.

C-2 control check - no selenate applied

D-2 22 cc. stock solution / 1 qt. H_2O approximately 1/36 qt. / 1 qt. H_2O.

The stock solution used was the same as that used in test #1, 49.75 grms. sodium selenate in one quart of water.

Concentrations of stock solution applied Feb. 18th, 1948.

25 Feb. 1948

A-2

# leaves	1	2	3	4	5	6	7	8	9	10	total
# spiders											
young plants	12	1	1	0	2	1	12	8	7	23	67
old plants	1	1	0	0	10	1	0	2	0	0	15

B-2

# spiders											
young plants	3	0	0	5	0	0	2	1	3	0	14
old plants	1	0	0	4	3	0	0	1	2	0	11

C-2

# spiders											
Young plants	8	6	0	27	7	4	0	1	0	0	53
old plants	1	0	3	2	9	0	3	1	0	0	19

D-2

# spiders											
young plants	0	0	4	0	0	1	0	2	0	35	41
old plants	1	8	6	5	3	20	0	0	2	2	49

3 March 1948

A-2

# leaves	1	2	3	4	5	6	7	8	9	10	total
# spider young plants	5	2	2	11	3	2	2	4	18	10	59
old plants	6	0	13	2	19	1	0	14	0	2	28

B-2

# spider young plants	6	1	0	4	1	6	5	17	3	4	47
old plants	0	1	0	4	1	2	2	0	1	1	12

C-2

# spider young plants	1	1	0	1	16	0	3	5	2	5	34
old plants	4	8	3	1	0	3	1	10	0	1	31

D-2

# spider young plants	4	0	0	1	12	0	0	2	0	0	19
old plants	0	4	0	0	17	2	4	1	1	3	32

10 March 1948

A-2

# leaves	1	2	3	4	5	6	7	8	9	10	total
# spider young plants	0	7	1	4	2	1	0	24	2	3	46
old plants	2	2	0	7	0	37	2	0	2	14	66

B-2

# spider young plants	8	1	0	7	1	2	1	12	5	0	37
old plants	1	0	0	0	0	4	7	0	0	2	14

C-2

# spider young plants	0	1	4	6	13	33	0	4	0	0	61
old plants	5	0	2	1	70	16	16	3	1	41	166

D-2

# spider young plants	0	0	0	0	0	0	0	0	0	0	0
old plants	0	4	1	0	2	4	4	0	0	7	22

D-2 young plants show slight selenium burn

17 March 1948

A-2

# leaves	1	2	3	4	5	6	7	8	9	10	total
# spider young plants	0	4	0	0	1	1	0	0	1	1	8
old plants	1	21	0	25	0	1	0	2	0	2	51

B-2

# spider											
young plants	0	0	0	1	0	0	0	0	0	0	1
old plants	0	0	0	0	0	0	1	0	0	0	1

C-2

# spider											
young plants	0	17	1	3	9	1	21	8	0	0	60
old plants	0	7	2	0	32	0	3	10	3	0	57

D-2

# spider											
young plants	0	0	0	0	0	0	0	0	0	0	0
old plants	0	2	0	0	1	0	0	0	1	0	4

D-2 young plants show severe burn

old plants show slight burn

24 March 1948

A-2

# leaves	1	2	3	4	5	6	7	8	9	10	total
# spider young plants	0	0	0	0	1	1	0	0	0	0	2
old plants	0	1	0	4	0	1	0	0	0	0	6

B-2

# spider young plants	0	0	0	0	0	0	0	0	0	0	0
old plants	0	1	0	0	0	0	0	0	0	0	1

C-2

# spider young plants	24	8	20	14	12	6	18	17	10	8	137
old plants	3	14	7	9	13	4	3	0	15	16	84

D-2 young plants severely burned

old plants severely burned

31 March 1948

A-2

# leaves	1	2	3	4	5	6	7	8	9	10	total
# spider young plants	0	0	0	0	0	0	0	0	0	0	0
old plants	0	2	0	0	0	0	3	0	2	0	7

B-2

# spider young plants	0	0	0	0	0	0	0	0	0	0	0
old plants	2	0	0	3	0	0	0	0	0	1	6

C-2

# spider young plants	13	12	22	18	13	7	23	8	18	17	151
old plants	2	66	7	4	26	12	8	22	13	42	242

D-2 young plants severely burned
old plants severely burned

B-2 young plants - growth seemingly reduced
old plants - growth seemingly reduced

7 April 1948

A-2

# leaves	1	2	3	4	5	6	7	8	9	10	total
# spider young plants	0	0	0	0	0	0	0	0	0	0	0
old plants	0	0	0	0	0	1	2	1	0	1	5

B-2

# spider young plants	1	0	0	0	0	0	0	0	0	0	1
old plants	0	0	0	1	0	0	0	0	0	0	1

C-2

# spider young plants	5	14	25	7	8	30	2	8	23	7	130
old plants	17	18	60	19	12	8	23	20	14	18	209

B-2 young plants - growth seemingly reduced

old plants - growth seemingly reduced

14 April 1948

A-2

# leaves	1	2	3	4	5	6	7	8	9	10	total
# spider											
young plants	0	0	0	0	0	0	1	0	0	0	1
old plants	0	2	0	0	0	0	0	1	0	0	3

B-2

# spider											
young plants	0	0	0	0	0	1	0	0	0	0	1
old plants	0	0	0	0	0	0	0	0	0	0	0

C-2

# spider											
young plants	32	36	12	29	17	6	15	41	4	19	211
old plants	16	66	28	32	13	22	25	37	9	33	281

B-2 young plants - growth reduced about 10%

old plants - growth reduced about 10%

WEEKLY TOTALS

	25 Feb.	3 Mar.	10	17	24	31	7 Apr.	14
A-2								
new	67	59	46	8	2	0	0	1
old	15	58	66	51	2	7	5	3
B-2								
new	14	47	37	1	0	0	1	1
old	11	12	14	1	1	6	1	0
C-2								
new	53	34	61	60	137	151	130	211
old	19	31	166	57	84	202	209	281
D-2								
new	41	19	0	0	-	-	-	-
old	49	32	22	4	-	-	-	-

ANALYSIS OF TEST #2

Approximately two and one half weeks after treatment the young plants in area D started to show signs of burn and a short time thereafter both young and old plants showed signs of burn. This supported the evidence gained in test #1 - namely, that the plants were injured when 20 cc. or more of the stock solution was applied to a six square foot area.

Attention then centered around the two remaining plots - A, treated with eight cc. and B, treated with ten cc. In both instances the population fell off markedly, but with the difference that in B growth was retarded for some time. Five weeks after treatment plants in area B seemed to lack the height of the plants in the untreated control check. About three weeks after the difference became apparent the plants seemed to overcome the lack of growth, and in comparison with the control check, seemed to be growing normally, as can be seen in the accompanying picture.

Perhaps the growth was permanently retarded and only seemed to regain vigor when the plants of the control check were seriously affected by spider and plant vigor was affected. In other words, both the control check and area B plants may have had reductions in growth, but since the former was affected by spider and the latter affected by the selenate no differences were apparent. At any rate the difference first noticed in area B would have little bearing on the quality of the plant for, as mentioned in test #1, these plants are not sold on a height basis.

Plants in area A seemed to grow at a normal rate but, although the population fell off considerably in comparison with the control plot, all the spiders were not killed by the concentration applied. For this reason it is advised that solutions stronger than 8 cc./6 square feet be used on ageratum. The possibilities of re-infestation seem to make it inadvisable that such a light treatment be used, although the spiders were not in great enough number to cause plant injury. In a commercial greenhouse ageratum may be placed near other plants that are very susceptible to spider attack and the presence of spider on ageratum, while not affecting that plant, may easily lead to a heavy infestation on neighboring plants.

The addition of sand to the soil seemed to have an effect on absorption of selenate by the plant, if we can use plant tolerance as a measure of comparison. In test #1 plants treated with 14.75 cc. showed a slight decrease in growth and height. In that case no sand was added to the soil. In test #2, with sand added to the soil, plants with less selenate added (10 cc.) showed almost the same lack of growth. If the conditions were equal as regards growing medium, it is probably safe to assume that plants treated with 10 cc. should show less loss of height. Investigators in the past have found that sand will have a positive effect on the amount of selenate absorbed, and it is logical to state that, in this instance, the sand added in test #2 aided in selenate absorption by the plant. This phenomena was recorded by Hurd-Karrer (1938) and seemed to be borne out in this instance.

The most beneficial concentration indicated by these tests is 10 cc. of stock solution per 6 square feet of bench area. With this concentration the spider population was 1 spider per ten leaves examined compared to an average of 245 spiders per ten leaves in the untreated check plot. The differences in growth, noticed at one time, are probably negligible as regards commercial value of the plants, and control of the spiders can be expected one month after application of the insecticide to the soil.

SODIUM SELENATE

PLANT ON THE LEFT IS INFESTED WITH RED SPIDER. EVIDENCES OF THEIR INJURY CAN BE SEEN BY THE FADED, MOTTLED, AND LIGHT COLORED FOLIAGE. PLANT ON THE RIGHT IS FROM PLOT B WHICH WAS TREATED WITH 10 cc. OF STOCK SOLUTION PER 6 SQUARE FEET OF BENCH AREA. THESE PLANTS ARE TAKEN FROM THE SECTION LABELLED "OLD PLANTS", AND WERE SUBJECT TO THE SAME GROWING CONDITIONS, WERE OBTAINED FROM THE SAME STOCK, AND ARE BOTH THE SAME AGE.

photo by Robert Coffin.

SODIUM SELENATE

PLANT ON THE LEFT IS INFESTED WITH RED SPIDER. BOTH THESE PLANTS ARE COMPARABLE TO THE PLANTS ON THE PREVIOUS PAGE WITH THE EXCEPTION OF AGE. THESE ARE BOTH ONE MONTH YOUNGER THAN THOSE ON THE PRECEEDING PAGE. THE INFESTED PLANT WAS TAKEN FROM THE UNTREATED CHECK PLOT AND THE HEALTHY PLANT WAS TAKEN FROM PLOT B, WHICH WAS TREATED WITH 10 cc. OF STOCK SOLUTION PER 6 SQUARE FEET OF BENCH AREA.

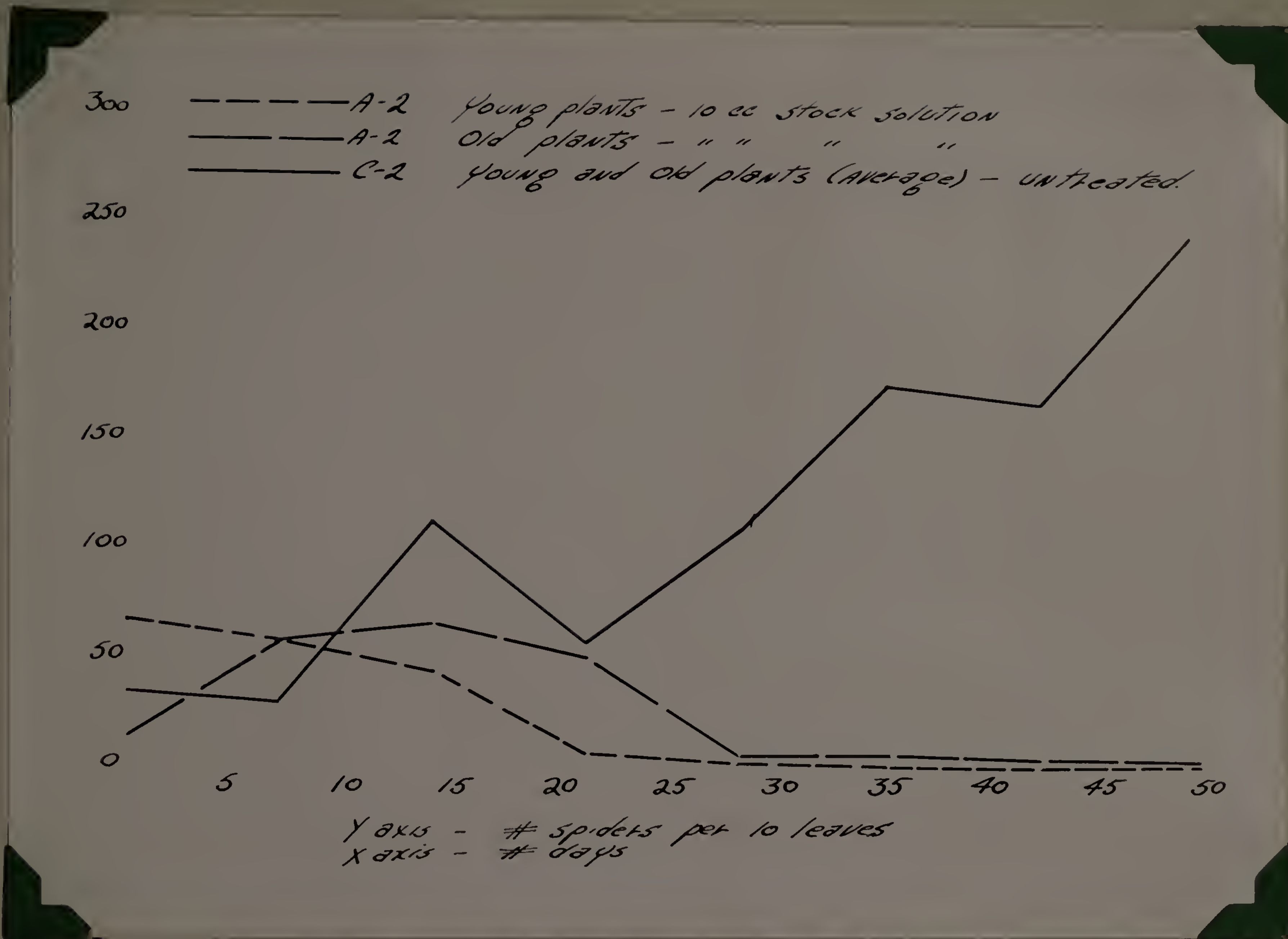
SODIUM SELENATE

OLD PLANTS

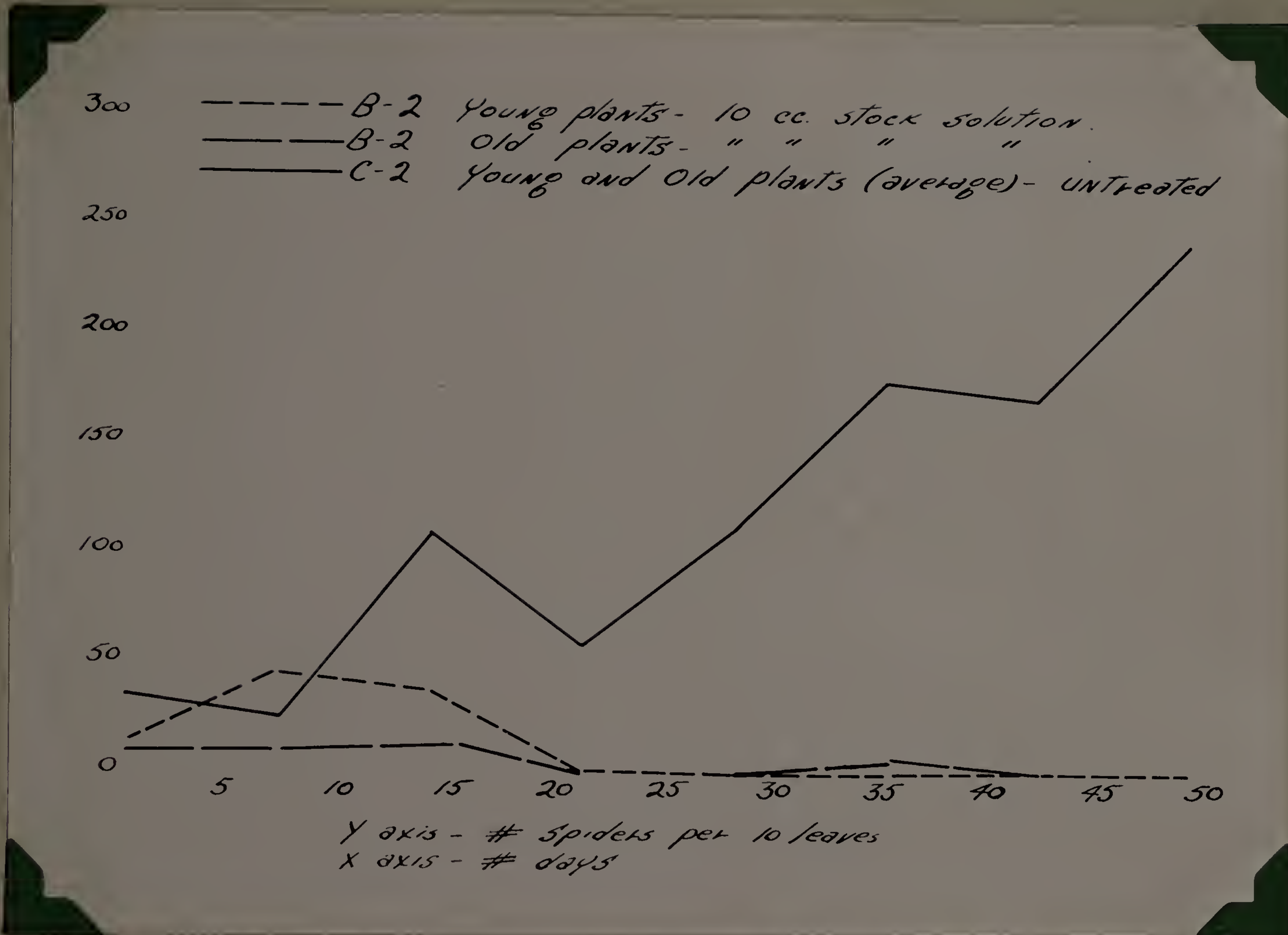
TYPICAL LEAVES TAKEN FROM INFESTED PLANTS SHOWN ON THE LEFT AND CENTER. LEAF TAKEN FROM PLANT TREATED WITH 10 cc. PER SIX SQUARE FEET OF BENCH AREA SHOWN ON RIGHT.

YOUNG PLANTS

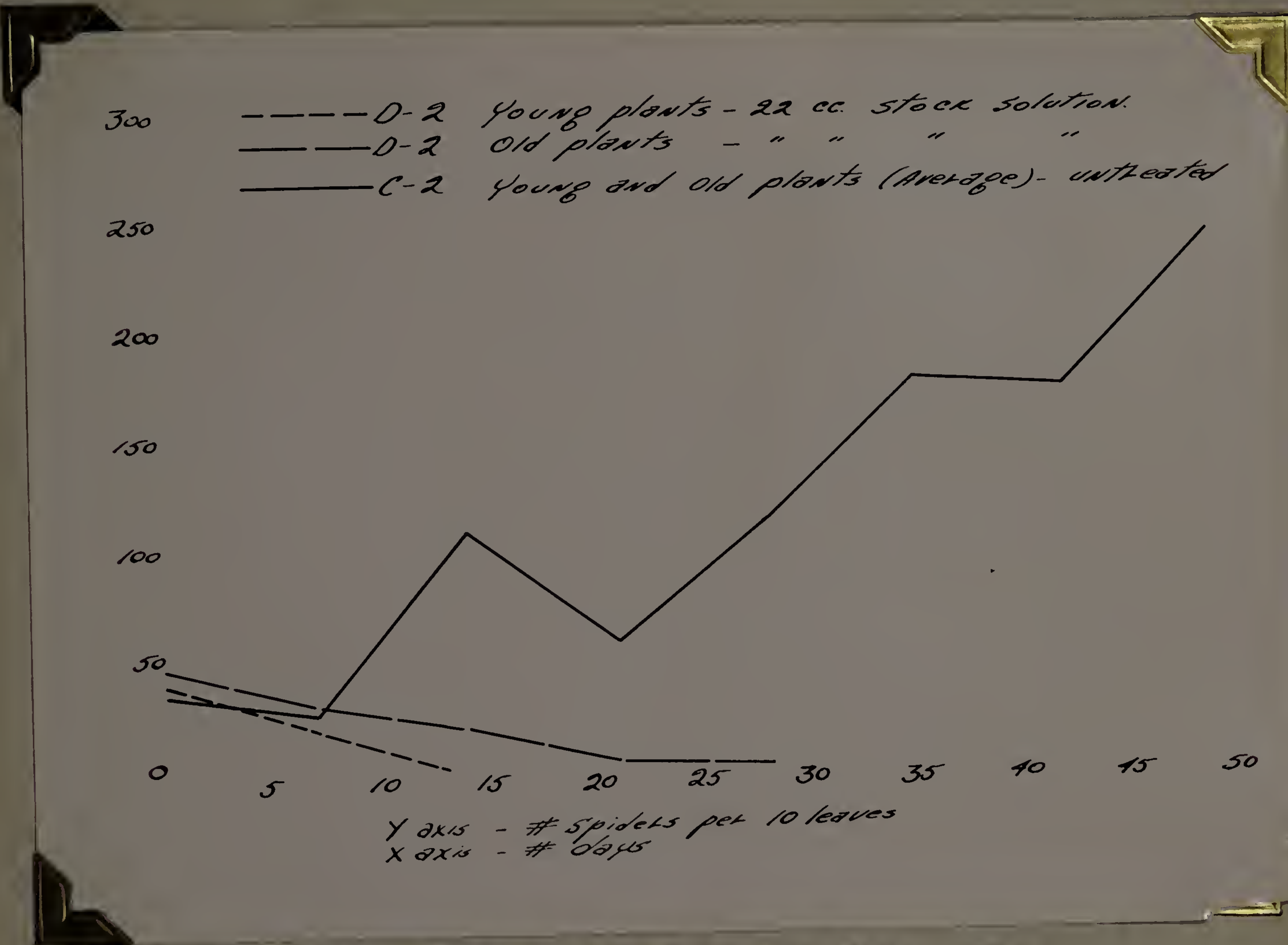
TYPICAL LEAVES TAKEN FROM INFESTED YOUNG PLANTS SHOWN ON THE LEFT AND CENTER. LEAF TAKEN FROM PLANT TREATED WITH 10 cc. PER SIX SQUARE FEET OF BENCH AREA SHOWN ON RIGHT.



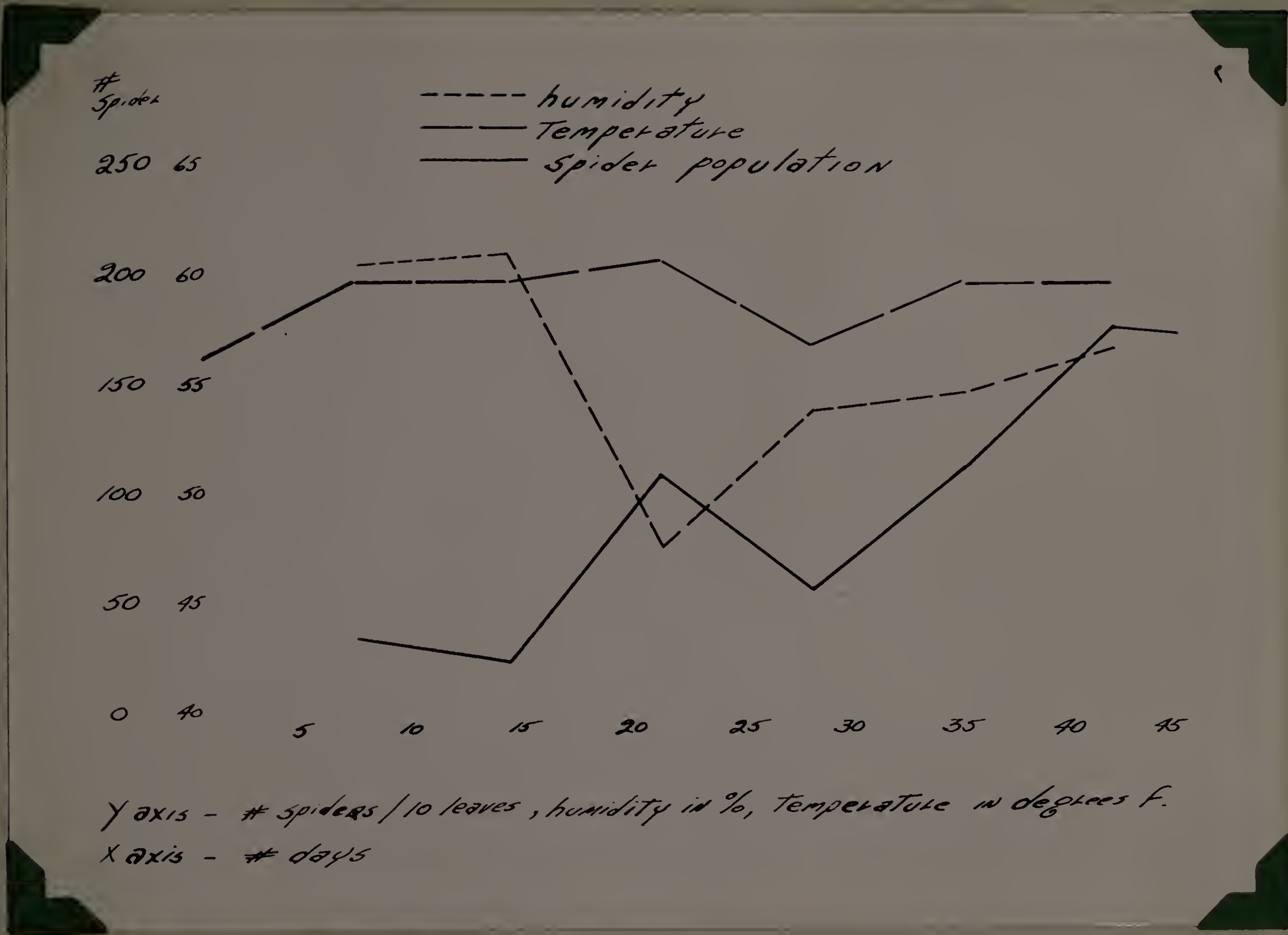
Spider population plotted against time in days. The young and old plants of A-2 were treated with 8 cc. of stock solution diluted in 1 quart of water and sprayed on six square feet of bench area. The untreated young and old plants of the control check plot are shown by the solid line.



Spider population plotted against time in days. The young and old plants of B-2 were treated with 10 cc. of stock solution diluted in one quart of water and sprayed on six square feet of bench area. The untreated young and old plants of the control check plot have their spider populations averaged and are indicated by the solid line.



Spider population plotted against time in days. The young and old plants of D-2 were treated with 22 cc. of stock solution diluted in one quart of water and sprayed on six square feet of bench area. The untreated young and old plants of the control check plot have their spider population averaged and are indicated by the solid line.



This graph is shown as a possible explanation for the sudden rise in insect population in the control check plot. By referring to page 45 it can be seen that the population count on March 10th for the area C-2 showed a gain that seems out of proportion to previous increments of population. The above graph shows the average humidity and temperature readings for the period that the plants were observed. The data was obtained from a thermograph and humidograph that were kept in directly above the test plots during the course of the experiments.

A review of information on the favorable ecologies for red spider development will show that they prefer dry environments for optimum development. With this fact in mind the temperature and humidity were plotted against the population of the control check plots. The line indicating the temperature and the line indicating the humidity were both plotted one week behind the population. It is apparent that a change in temperature would not show immediate effects on the population. Since the life cycle runs a little more than one weeks time at this time of the year according to Whitcomb and Guba (1930) the temperature and humidity lines were moved back approximately one week to allow some time for the effects to show on the population plotted on the graph. In a simple way the population was allowed to "catch up" with the effects of temperature and humidity for the purposes of showing a possible relation between physical factors and insect population as plotted on the graph.

It can be seen that when the humidity dropped steeply the population rose almost at an exact inverse rate. It is impossible to say that this physical change is the cause of the rise in population but it is interesting to note the apparent relationship between the two.

This still leaves the population count of the following week (March 17th) unexplained. Referring to page 45 again it can be seen that the population declined when normally it should at least remain at the same level as the previous week - March 10th. This decline may be explained by the corresponding increase in humidity or by the fact that the population may have reached its limits on the plant or leaves examined and lack of food coupled with less favorable physical conditions caused a decline in population.

The above theories are by no means established but are offered as a possible explanation for the erratic behavior in the instance mentioned.

P-40

Purpose.

The purpose of these tests was to determine if sodium selenate in the form known as P-40 could be used on ageratum for the successful control of red spider. P-40 is the 2% sodium selenate with superphosphate as a carrier. It is used as a powdered soil insecticide and is usually placed on the top of the soil to be treated and washed in with a light water spray. Its action is similar to that of pure sodium selenate with the exception that it is not so strongly concentrated and hence can be handled easier.

In greenhouse work its main use is in connection with potted plants. The insecticide is applied to the individual pots by means of a measuring spoon. The dosages depend on the type of plant and the size of the pot and the general dosages run in fractions of spoonfuls.

P-40 is usually slower acting than the purer forms of selenate, but presents the advantages of safer handling and greater accuracy of dosage applied. Care should be taken in the greenhouses that it is not used as a fertilizer, and all containers should be plainly marked to that effect.

Method.

The plants used were approximately three months old, which would be the age of ageratum stock plants used for cuttings in a commercial greenhouse. Previous to the test the plants were cut back and the dead leaves were stripped off. They were then fertilized and allowed to grow on the bench for a period of one week before any insecticide was applied. This was necessary since the plants were not in good growing condition and it seemed best to strengthen their growth before treatment to approximate field conditions more closely. Before the test the plants were moved from 3" to 4" pots and fertilized soil was added. The bulk of the soil in the pots was similar to the type soil used in test #1, a medium loam.

Four plots were arranged, each consisting of two rows of four pots each, making a total of thirty two pots. Plot A received one level measuring spoonful of P-40 per pot, plot B received ½ a measuring spoonful, and plot D received ¼ spoonful on April 13th. Plot C, the control check plot was left untreated. All the plants were placed on top of a sand filled greenhouse bench.

The insecticide was placed on the top of the soil level in each pot and the four plots were then watered using a fine spray nozzle so that the powder was not washed over the sides of the pots. This spraying aids in distributing the insecticide through the lower reaches of the soil, and helps to wash any signs of the P-40 powder from the lower leaves of the plants. As in the case of the purer forms of sodium selenate care must be taken to make certain that no insecticide is left on the foliage or any aeriel parts of the plant. If it is not all removed the insecticide will probably burn those sections that have traces of the powder remaining on it for more than several days.

The method of sampling and recording populations was the same as the methods used in all the tests. Periodically leaves were taken from the plants and examined under a microscope and the number of spiders present was recorded.

27 April 1948

A

# leaves	1	2	3	4	5	6	7	8	9	10	total
# spider	2	5	4	14	0	1	6	0	3	1	36

B

# spider	16	2	0	1	1	13	6	4	0	4	47

C

# spider	0	14	6	19	3	25	8	3	0	0	78

D

# spider	5	7	0	0	16	12	4	1	1	9	55

P-40 Control Check

May 3, 1948

A

# leaves	1	2	3	4	5	6	7	8	9	10	Total
# spider	0	0	2	5	4	0	0	0	0	3	14

B

# spider	0	2	25	1	24	2	2	1	3	5	65

C

# spider	2	22	3	11	9	16	5	48	23	2	141

D

# spider	8	3	9	55	3	5	5	33	26	0	147

6 May 1948

A

# leaves	1	2	3	4	5	6	7	8	9	10	total
# spider	0	0	1	0	0	0	0	1	0	0	2

B

# spider	0	2	3	0	2	0	1	0	0	0	8

C

# spider	41	11	1	10	4	93	11	1	54	31	257

D

# spider	25	2	0	4	20	14	41	4	16	0	126

10 May 1948

A

# leaves	1	2	3	4	5	6	7	8	9	10	total
# spider	0	0	0	0	0	0	0	0	0	0	0

B

# spider	1	0	0	1	1	0	0	0	1	0	4

C

# spider	0	9	2	19	12	39	7	20	14	18	141

D

# spider	0	1	3	1	1	3	0	1	0	4	14

A - plants showing signs of selenium burn

ANALYSIS OF DATA

Four weeks after application of the insecticide to plants in plot A they showed signs of burn, indicating that the treatment of one full measuring spoon of the insecticide was impracticable. Plants in plot B and D seemed to be thriving fairly well. The plants showed an increase in new green foliage and the general health of the plant appeared normal. Under microscopic examination, however, plants treated with 1/4 measuring spoonful showed 14 spiders per ten leaves examined. In spiders per leaf this figure does not represent a population great enough to cause any visible damage, but as mentioned in analysis of previous tests, it is not advisable to allow even such small infestations to exist if it is possible to exercise a better degree of control, since plants in a commercial greenhouse may be the source of infestation in neighboring plants.

The results of the tests show that for maximum control with least injury (in this case none at all) P-40 should be applied at the rate of 1/2 measuring spoonful of the insecticide per 4" pot. Approximately one month after the insecticide was applied these plants showed 4 spiders per ten leaves compared to the check plants which had 141 spiders per ten leaves examined.

PARATHION

Introduction and history.

In the opinion of Dr. W.E. Blauvelt, as stated in a 1948 New York Flower Growers' Bulletin, the new insecticide known as Parathion shows promise of being the most important material yet discovered for chemical control of greenhouse pests. Its widespread uses show it to be a veritable boon for greenhouse growers. While it is not necessarily limited to greenhouse use its effects on insects seem to indicate that it may receive great application as such, since it is most effective against almost all of the major greenhouse pests. Recently conducted tests have shown that in aerosol form it is effective against aphids, thrips, mealybugs, white fly, broad mite, cyclamen mite (on exposed surfaces), greenhouse leaf tyer, rose leaf roller, greenhouse millipds, sowbugs, pillbugs, and red spider mite. In fact according to the same bulletin it has been effective against every pest treated.

Chemically, Parathion is 0,0-diethyl -p-nitrophenyl thiophosphate, spoken as diethyl paranitrophenyl thiophosphate. However due to the inconveniences of such a lengthy name, Parathion has been selected as the approved common name, and the insecticide is usually referred to as such. It must be made clear that it is not necessarily manufactured under this name as some manufacturers will use various registered trade names.

Parathion was first brought to the attention of American growers and men engaged in research by the U.S. Department of Commerce which issued reports of the American and British scientific teams which investigated German scientific advances made during the war. The insecticide was discovered by the I.G. Farbin corporation as a result of research conducted on over 300 phosphorus compounds which was an outgrowth of their experiments on phosphorus-fluorine compounds for use as war gases. The material was labelled E-605, but the Germans apparently did not realize its potentialities as an insecticide since they did not seem to investigate its uses along these lines to any great extent.

At present, in this country, a great amount of investigation is being conducted on Parathion as an insecticide. Preliminary reports show a considerable degree of success but no extensive reports have been published.

What little has been published deals primarily with its use as an aerosol. This method has been selected to head the list of treatments to be investigated since the aerosol method has the advantage over spray and dust treatment. The ease of handling, speed of application, and labor saving costs of aerosol methods demand investigation before the less advantageous method of spray or dust. However, continued research may eventually show that its uses may be more fully realized as a dust or spray.

Purpose and method.

The purpose of these tests was to determine the insecticidal value of three different concentrations of Parathion in the dust form in controlling red spider on ageratum.

Four plots, each containing 20 plants, were arranged on greenhouse benches. The ageratum was about three months old but had been cut back to small size. This was necessitated by their poor condition previous to setting them up for experimentation. The plants had received little light previous to testing and, coupled with insect attack, they showed a poor condition. The yellowed and dying leaves were stripped off and the plants were allowed to grow on the bench for a period of a week to get them in normal condition for testing purposes.

The various dusts were applied to the plants late in the afternoon 4 days previous to taking counts of the population. They were dusted late in the afternoon to insure a minimum of ventilation during treatment.

The plots containing 20 plants were divided into two sections after treatment. This was done to determine the speed of control. The check plot was also watered in this manner to provide a standard measure of comparison with the treated plots. The variability of data due to the effect of watering was then cancelled out since the check plot also had the effects of watering. In the past plants have been syringed to remove spiders and it seemed worthwhile to treat the check plot in a manner similar, as regards watering procedure to allow for fair comparison.

The plants were in 3 inch pots on benches filled with sand, as they are normally grown.

Explanation of data sheets:

plot A	1/4 % dust
plot B	1/2 % dust
plot C	control check - no treatment
plot D	1 % dust

the number -1 in the tables indicates it was the first series of tests with Parathion. The small letter "a" signifies that the plant was watered 48 hours after treatment, and the small letter "b" signifies that the plant was watered 72 hours after treatment.

The numbers in parentheses indicate that the spider found on those leaves was in an extremely young condition. All counts were taken in ten leaf groups, and were taken 4 days after treatment.

14 April, 1948

A-1a											
# leaves	1	2	3	4	5	6	7	8	9	10	total
# spider	0	0	0	0	0	0	0	0	0	0	0 (3)
A-1b											
# spider	0	0	0	0	4	0	0	0	0	0	4 (2)
B-1a											
# spider	0	1	0	0	0	0	0	0	0	0	1 (2)
B-1b											
# spider	0	0	0	0	0	0	0	0	0	0	0
C-1a											
# spider	12	19	1	16	24	11	0	25	8	14	130
C-1b											
# spider	28	28	17	24	28	15	25	7	3	20	195
D-1a											
# spider	0	0	0	0	0	0	0	0	0	0	0
D-1b											
# spider	0	0	0	0	0	0	0	0	0	0	0

3 May 1948

A-1a

# leaves	1	2	3	4	5	6	7	8	9	10	total
# spider	0	36	23	5	0	10	8	15	9	6	112

A-1b

# spider	3	11	48	93	24	0	0	37	4	10	230

B-1a

# spider	43	0	7	3	7	4	31	15	2	0	112

B-1b

# spider	22	3	60	63	43	42	0	18	1	0	242

C-1a

# spider	65	43	42	10	1	25	71	36	23	42	358

C-1b

# spider	35	73	0	5	62	22	25	3	77	14	316

D-1a

# spider	7	3	0	0	14	1	0	0	7	0	32

D-1b

# spider	13	0	23	0	36	6	6	3	1	12	100

6 May 1948

A-2

# leaves	1	2	3	4	5	6	7	8	9	10	total
# spider	0	0	0	0	0	0	1	0	0	0	1

B-2

# spider	0	0	0	0	0	0	0	0	0	0	0

C-2

# spider	14	27	14	0	8	22	33	12	59	5	194

D-2

# spider	0	0	0	0	0	0	0	0	0	0	0

PARATHION

UNTREATED PLANT ON THE LEFT SHOWS THE DISCOLORATION DUE TO RED SPIDER INJURY. PLANT ON THE RIGHT HAS BEEN TAKEN FROM AREA D, DUSTED WITH 1% PARATHION.

CENTER LEAF AND LEAF ON THE LEFT TAKEN FROM THE UNTREATED PLANT SHOWN ABOVE. LEAF ON RIGHT TAKEN FROM TREATED PLANT SHOWN ABOVE.

ANALYSIS OF DATA

The results of the first tests indicated several facts. First, the watering of the plants 48 hours after treatment showed little difference with the results obtained with watering similarly treated plants 72 hours after treatment. In all cases the difference was so slight that it seemed impracticable to investigate any further the effects of watering the plants at definite periods of time after treatment.

Secondly, while taking the counts of the insect population, it was noticed in several instances that on treated leaves tiny red spider larvae were present, although there were no other walking stages in evidence. There were not enough larvae present to assume that this stage was not affected. It seems, rather that the egg stage was uneffected.

The probable explanation is that the egg stage remains unaffected by the insecticide and after the dust has been washed off the leaves, the larvae hatch from the unaffected egg and can feed on a leaf that is not toxic to them. This seems to be confirmed in other work since it has been advised by Blauvelt (1948) that several dustings or treatments be used to completely break the life cycle.

In all tests a large percentage of kill was obtained but the re-infestation was heavy. This is probably due to the reason mentioned in the previous paragraph. In a sense it is difficult to recommend the percentage of concentration to be used. Even the lowest percentage showed excellent control and since there is no plant injury even when the strongest concentration is used, it would seem that there would not be too much difference which concentration was used. If there is not too great a difference in the price range of the insecticide it would probably be best to use the strongest concentration of the insecticide, to be on the safe side.

In the opinion of this writer best control can be secured by dusting several times within the period of seven to ten days with 1% Parathion. Since this is the duration of the red spider life cycle during the summer, this method will catch the larvae that develop from eggs which have been left unaffected by previous dustings. This method of control seems generally advisable. Parathion merits use on ageratum since it is effective, easily applied and shows quick control.

CONCLUSIONS

Red spider on ageratum can be controlled to an excellent degree by the proper use of sodium selenate and/or Parathion.

In using sodium selenate a stock solution of 199 grams of the chemical diluted in one gallon of water should be prepared. This should be applied to the bench soil at the rate of 10 cc. of stock solution diluted in one quart of water and applied to 6 square feet of bench area. Plants that are placed in the bench so teated should be established in pots for three to four weeks after removal from the propogation beds, since plants younger than this can be burned by the action of selenate. Control can be expected within one month after placing the plants in the treated soil.

P-40 can be used for potted plants at the rate of ½ a measuring spoonful per 4" pot. This method is best used for plants that are in pots since it presents a more accurate method of treatment for individual plants. Control can be expected one month after treatment.

Parathion is the quickest acting method of control of the insecticides studied, but must be applied several times before 100% control is realized. It should be applied in the 1% concentration and control can be expected after several dustings in the seven to ten day period.

For a commercial grower handling ageratum on a large scale it seems best that the sodium selenate be used on the plants that are kept overwinter for the next seasons' stock plants. These plants can be treated with the slower acting control - sodium selenate - since a quick control is not necessary unless, of course, the original infestation is of such an intensity that a quick control is necessary. In this way he can treat the plants once and will not have to retreat until they are used for cuttings.

During the spring and summer season when the stock is being expanded and the sale of plants calls for quick going and turnover, Parathion can be used for a quick effective control if the plants should become infested with red spider.

In using all these insecticides care must be taken in handling the materials used. Sodium selenate has been proven to be very toxic to many animals and its effects may be very serious to man. Parathion has the potentialities of being toxic to man, and until more specific information can be obtained it should be handled with care.

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Date June 1948